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None

(58) Field of search
UK CL (Edition F) H1Q

(54) **Antenna arrangement**

(57) An antenna arrangement includes a dielectric lens (10), a primary antenna (20) and a reflect-array (30). Each element (31) in the reflect-array is provided with a phase shifting circuit, for example a p.i.n diode or a varactor diode. In the case of an antenna arrangement used as a receiver, for example, the distribution of phases across the array can be adjusted to synthesise, in respect of radiation incident in a particular direction, a reflected beam consistent with achieving a focus at the primary antenna. By appropriately varying the distribution of phases the response beam can be steered across a scene in accordance with a desired scanning format.

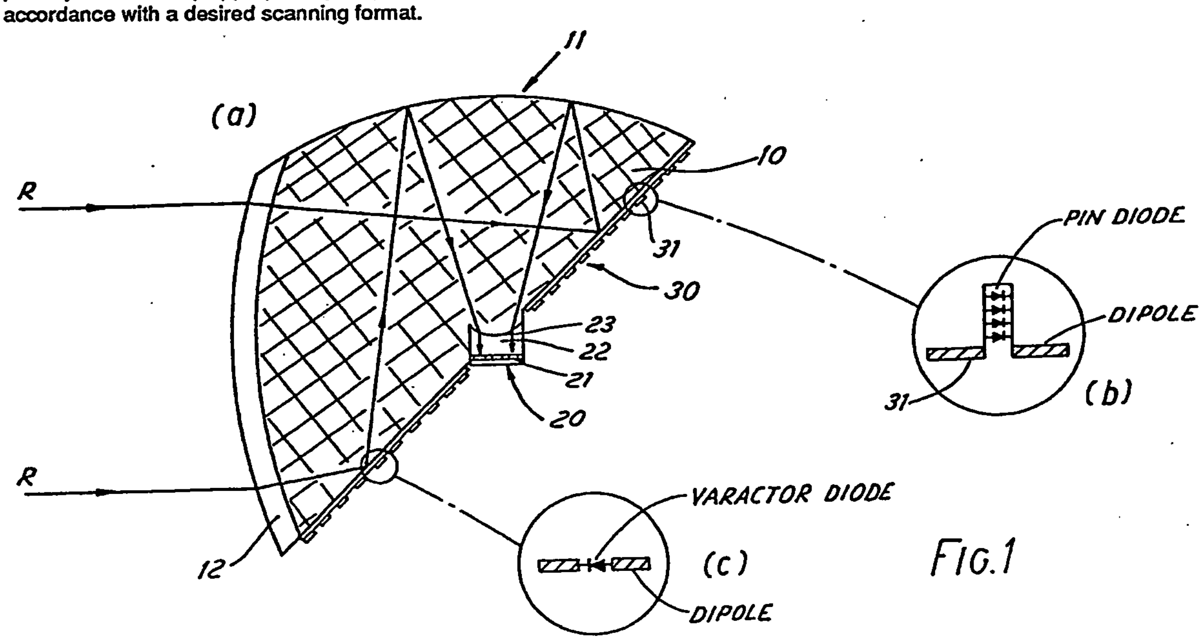

FIG.1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1990.

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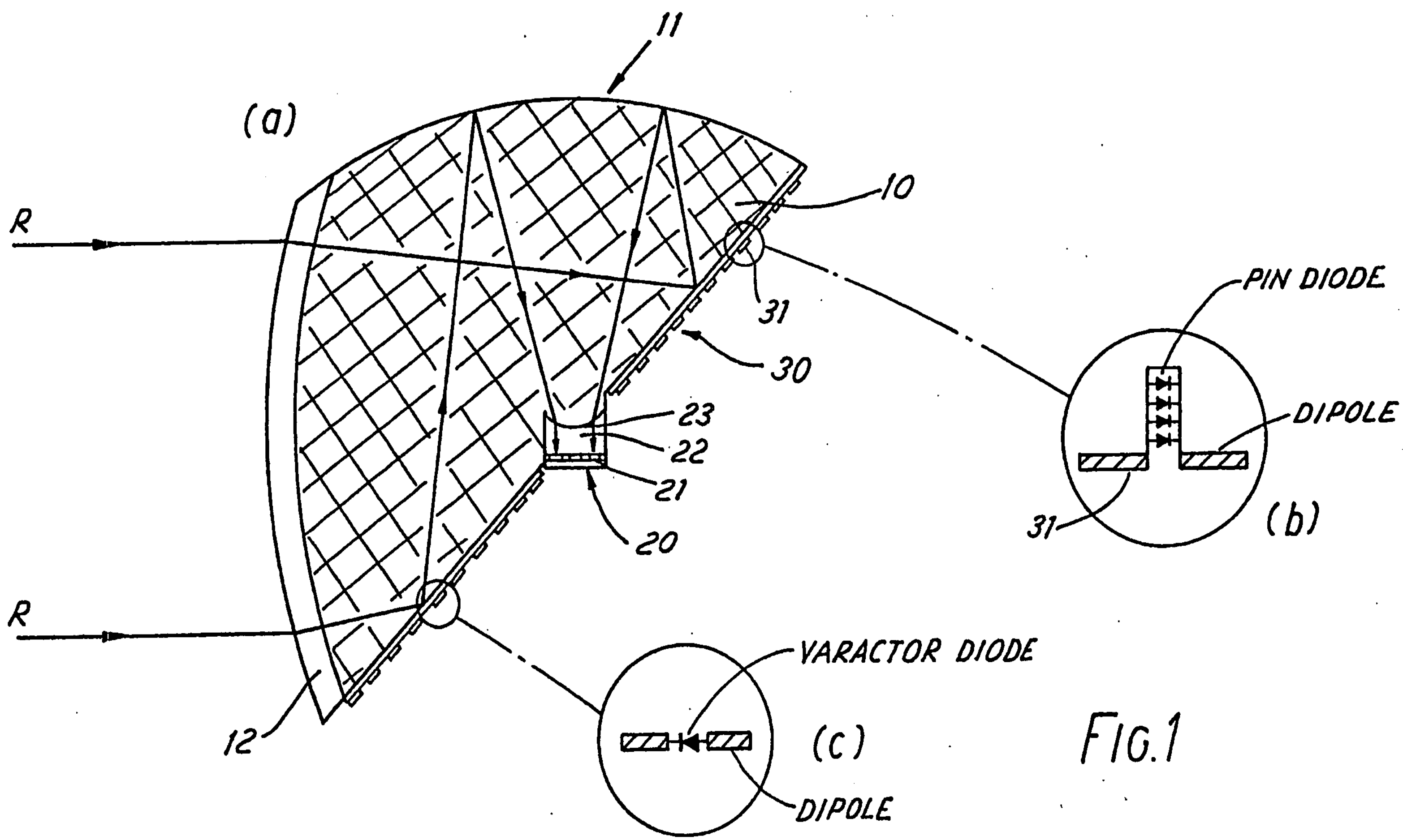

11
(a)
10
R
31
PIN DIODE
30
DIPOLE
23
22
21
20
31
(b)
R
VARACTOR DIODE
12
(c)
DIPOLE

FIG.1

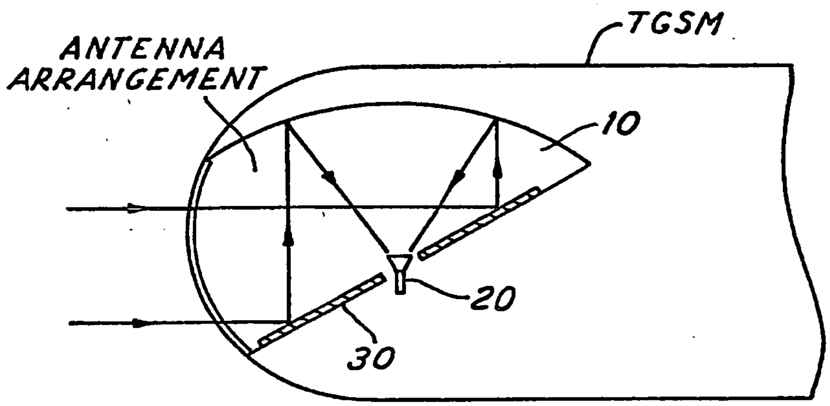


FIG.2

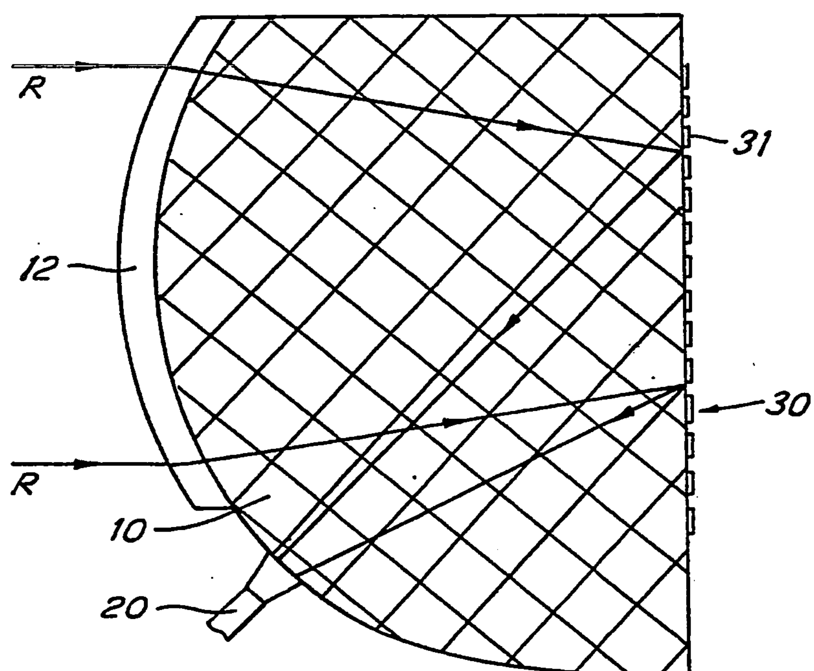


FIG.3

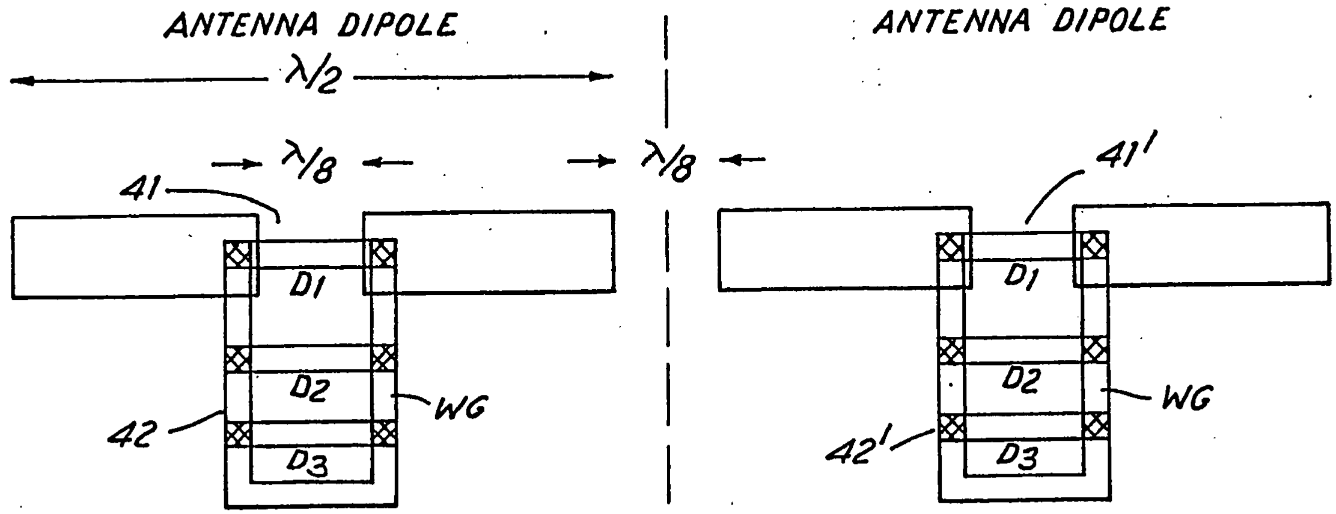
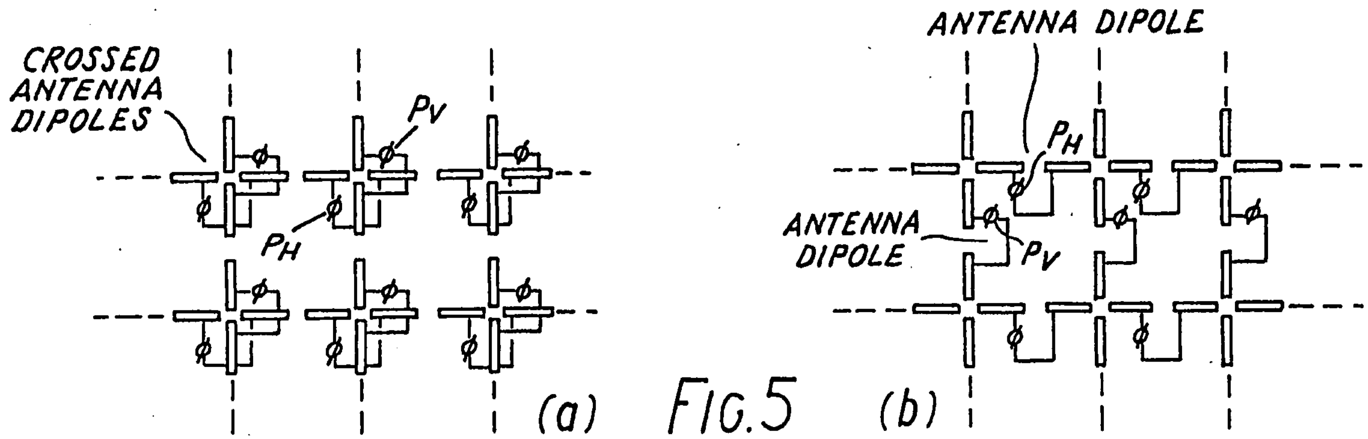

ANTENNA DIPOLE
$\lambda/2$
$\lambda/8$
41
D1
D2
D3
42
WG
$\lambda/8$
ANTENNA DIPOLE
41'
D1
D2
D3
42'
WG

FIG.4


CROSSED ANTENNA DIPOLES
PV
PH
ANTENNA DIPOLE
PH
ANTENNA DIPOLE
PV

(a) FIG.5 (b)

ANTENNA ARRANGEMENT

This invention relates to an antenna arrangement and it relates especially, although not exclusively, to an antenna arrangement used in a Terminally-Guided Sub-Munition (TGSM).

It is desirable that a TGSM should be fitted with a nose-mounted detection system capable of correctly identifying an armoured target even in the presence of ground clutter and other false targets. Passive IR systems have been proposed but these suffer from the disadvantage that their operation is degraded in the presence of aerosols such as fog or cloud. A system operating at millimetric wave-length is preferred but hitherto it has been usual to mount the receiver in a complex mechanical gimbal arrangement to scan the beam. Generally this proves to be inconvenient when space is limited as is the case in the nose portion of a TGSM and the requirement for low cost is a significant factor.

It is an object of the present invention to provide another form of antenna arrangement.

Accordingly, there is provided an antenna arrangement comprising a dielectric lens, a primary antenna and a planar array of secondary antenna elements arranged to reflect radiation propogating in said dielectric lens, wherein said array is provided with means for varying, in a controllable manner, the phase of radiation reflected at respective elements in the array, and the array is positioned fixedly in relation to said primary antenna and to said lens so that, in dependence on

the phase of radiation reflected at respective elements in the array the response pattern of said primary antenna points in a desired direction.

By varying, in a prearranged manner, the phase of radiation reflected at respective elements in the array the antenna response pattern can be steered in accordance with a desired scanning format. In an embodiment, the dielectric lens is provided with a reflective surface for reflecting radiation propagating between said array and the primary antenna.

According to another aspect of the invention there is provided a Terminally-Guided Sub-Munition fitted with an antenna arrangement as set forth in the two immediately preceding paragraphs.

Specific embodiments of the invention are now described, by way of example only, by reference to the Figures of the accompanying drawings of which:

Figure 1a shows a side elevation sectional view of an antenna arrangement,

Figure 1b shows schematically, on an enlarged scale, a single antenna element provided with a p.i.n. diode phase shifting circuit,

Figure 1c shows schematically, on an enlarged scale, a single antenna element provided with a varactor diode phase shifting circuit, as an alternative to the p.i.n. diode phase shifting circuit of Figure 1b.

Figure 2 shows a side sectional view through a TGSM fitted with an antenna arrangement,

Figure 3 shows a side elevation sectional view of another antenna arrangement,

Figure 4 shows schematically two linear dipoles forming part of a reflect array and their respective phase shifting circuits,

Figures 5a and 5b show alternative configurations of dual polarisation dipoles in a reflect array.

Figure 1a shows a side elevation sectional view of an antenna arrangement used as a receiver. This arrangement is designed primarily for mounting in the nose portion of a missile (e.g. a Terminally-Guided Sub-Munition (TGSM)) as is illustrated schematically in the side view of Figure 2. It will be appreciated, however, that the present invention is useful in other applications requiring a steered response beam.

The arrangement shown in Figure 1a comprises a dielectric lens 10, a primary antenna 20 and a planar reflect-array 30 including a plurality of discrete antenna elements 31. The lens which may be of alumina, barium nonatitanate ($Ba_2 Ti_9 O_{20}$), polystyrene loaded with titanium or of another suitable dielectric material known in the art is provided with a parabolic reflective surface 11 formed of a layer of a reflective material such as gold or copper.

Radiation, represented by two exemplary rays R, is incident at a curved surface of the lens faced with a ¼ wave matching layer 12.

Incident radiation is refracted at layer 12 and then

reflected at array 30 towards the parabolic reflective surface 11 which focusses the radiation onto the primary antenna 20.

As will be described in greater detail hereinafter, and as is illustrated schematically on an enlarged scale in Figures 1b and 1c, each element in array 30 is in the form of a dipole and is provided with a phase shifting circuit to vary controllably the phase of radiation reflected at that element. The phase shifting circuits may be either p.i.n. diode circuits (one circuit for each dipole) or varactor diodes, as shown in Figures 1b and 1c respectively. If the distribution of phases across the entire array is adjusted suitably it is possible to synthesise, in respect of radiation incident at a selected angle, a reflected beam propagating in the lens in a fixed direction consistent with achieving a focus, and by appropriately varying the distribution of phases the response pattern of the primary antenna can be steered across a scene in accordance with a desired scanning format.

Figure 3 shows another embodiment of the present invention. In this example the parabolic reflective surface is absent and in these circumstances the phase distribution of radiation incident at the reflect-array is adjusted to provide the necessary additional focussing.

If a two dimensional reflect-array is used the response beam of the antenna arrangement can be steered in two orthogonal directions (e.g. in azimuth and in elevation) or alternatively if a one dimensional array is used scanning is possible in one

direction only usually, but not necessarily, in azimuth.

In the case of an antenna arrangement intended for use in a TGSM the radius of curvature of the matching layer 12, which conforms to the outer surface of the nose portion will typically be about 50 mm and in these circumstances a square reflect-array comprising 100 rows and 100 columns can be used, each element in the array having a dipole length of $\lambda/2$, and adjacent elements having a centre-to-centre spacing also approximately $\lambda/2$. At a typical operating frequency of 90 GHz the wavelength λ of radiation propagating in a suitable dielectric material (e.g. silicon or ceramic) is about 1.3mm.

If radiation of a single polarisation is to be received each element in the array may comprise a linear dipole formed by evaporating gold or copper, say, onto a dielectric substrate such as a ceramic e.g. alumina. If radiation of dual, or alternatively circular polarisation is to be received then cross dipoles are provided.

Alternatively, the array may have a monolithic structure and this may be fabricated using known IC techniques described, for example, in "Monolithic Integration of a Dielectric Millimetre Wave Antenna and Mixer Diode - An Embryonic Millimetre Wave IC" by Yao and Schwarz IEEE, Trans on Microwave Theory and Techniques Vol. MTT 30, No. 8 August 1982 p 1241-1246.

Figure 4 shows schematically in plan view two linear dipoles 41, 41' forming part of a reflect array each provided with a respective phase shifting circuit 42, 42' in the form of

three p.i.n. diodes D_1, D_2, D_3 connected in parallel across the dipole halves by means of a dielectric wave guide (WG). A selected one of the diodes is rendered electrically conductive by application thereto of a suitable biassing voltage and this results in a corresponding change in the reactance of, and so the phase of radiation reflected at the dipole. As will be apparent to persons skilled in the art, the phase shifting circuit can be dimensioned so that, when suitably biassed, diodes D_1, D_2 and D_3 produce respective phase shifts of 0°, 90° and 180° and a phase shift of 270° is produced when none of the diodes is biassed. Clearly more than three diodes may be provided, if desired, allowing a greater number of possible phase shifts.

If crossed dipoles are used then, as shown in Figure 5a, each of the orthogonally inclined limbs of a dipole is provided with a respective phase shifting circuit P_H, P_V. Alternatively, the limbs could be staggered as shown in Figure 5b, and clearly other configurations are possible.

At frequencies up to about 100 GHz instead of using a number of p.i.n. diodes it is possible to use a single varactor interconnecting the halves of each dipole. Such an arrangement is shown schematically in Figure 1c. This enables a continuously variable phase change to be produced if desired.

As illustrated in Figure 3 the primary antenna 20 may comprise a horn mounted at a surface of the lens. Alternatively, as shown in Figure 1a, antenna 20 may comprise a

further array 21 of discrete receiving elements mounted at the focal plane of the antenna arrangement at the centre of the reflect array.

In the example, described hereinbefore intended for use in a TGSM the further array may be typically 13 mm square and may comprise 16 x 16 elements. Again the elements may be fabricated by evaporating gold or copper, for example, on a ceramic substrate or alternatively they may be formed monolithically on a substrate of silicon using techniques described, for example, in the above-referenced article. The further array is provided with a collimating lens 22 formed of a material of high dielectric constant and having a concave surface 23.

It will be appreciated that although the above-described embodiment relates to a receiver, alternatively, by suitably feeding antenna 20 the antenna arrangement may be used as a transmitter or, when multiplexed, as a transmitter/receiver.

CLAIMS

1. An antenna arrangement comprising a dielectric lens, a primary antenna and a planar array of secondary antenna elements arranged to reflect radiation propogating in said dielectric lens, wherein said array is provided with means for varying, in a controllable manner, the phase of radiation reflected at respective elements in the array, and the array is positioned fixedly in relation to said primary antenna and to said lens so that, in dependence on the phase of radiation reflected at respective elements in the array the response pattern of said primary antenna points in a desired direction.

2. An antenna arrangement according to Claim 1 wherein said dielectric lens is provided with a reflective surface for reflecting radiation propagating between said array and said primary antenna.

3. An antenna arrangement according to Claim 1 or Claim 2 wherein said means for varying phase comprises respective diode circuits associated with the elements in the array.

4. An antenna arrangement according to Claim 1 or Claim 2 wherein said diode circuits are p.i.n. diode circuits.

5. An antenna arrangement according to Claim 1 or Claim 2 wherein said diode circuits are varactor diode circuits.

6. An antenna arrangement according to Claim 1 wherein said antenna elements comprise cross-dipoles, each limb of said cross-dipole being provided with a respective phase shifting circuit.

7. An antenna arrangement according to any one of Claims 1 to 6 wherein said primary antenna comprises an antenna horn.

8. An antenna arrangement according to any one of Claims 1 to 6 wherein said primary antenna comprises a further array of antenna elements at the focal plane of the antenna arrangement.

9. An antenna arrangement according to Claim 8 wherein said further array of antenna elements is provided with a collimating lens of a dielectric material.

10. A Terminally-Guided Sub-Munition including an antenna arrangement according to any one of Claims 1 to 9.

11. An antenna arrangement substatially as hereinbefore described by reference to and as illustrated in the accompanying drawings.

Amendments to the claims have been filed as follows

CLAIMS

1. An antenna arrangement comprising a dielectric lens, a primary antenna and a planar array of secondary antenna elements arranged to reflect radiation propogating in said dielectric lens, wherein said array is provided with means for varying, in a controllable manner, the phase of radiation reflected at respective elements in the array, and the array is positioned fixedly in relation to said primary antenna and to said lens so that, in dependence on the phase of radiation reflected at respective elements in the array the response pattern of said primary antenna points in a desired direction.

2. An antenna arrangement according to Claim 1 wherein said dielectric lens is provided with a reflective surface for reflecting radiation propagating between said array and said primary antenna.

3. An antenna arrangement according to Claim 1 or Claim 2 wherein said means for varying phase comprises respective diode circuits associated with the elements in the array.

4. An antenna arrangement according to Claim 3 wherein said diode circuits are p.i.n. diode circuits.

5. An antenna arrangement according to Claim 3 wherein said diode circuits are varactor diode circuits.

6. An antenna arrangement according to Claim 1 wherein said antenna elements comprise cross-dipoles, each limb of said cross-dipole being provided with a respective phase shifting circuit.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number 8317409.4

Relevant Technical fields (i) UK Cl (Edition F) H1Q (QEC, QFD, QFE, QFF, QFH and QFJ) (ii) Int Cl (Edition) NONE	**Search Examiner** H E GRIFFITHS
Databases (see over) (i) UK Patent Office (ii)	**Date of Search** 9 APRIL 1984

Documents considered relevant following a search in respect of claims 1 to 11

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

SF2(p)

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

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P: Document published on or after the declared priority date but before the filing date of the present application.

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